

6.2 THE PROPOSED FLATLAND RADAR

18947
J. L. Green, K. S. Gage, T. E. VanZandt,

Aeronomy Laboratory
Boulder, CO 80303

and

G. D. Nastrom

Control Data Corp
Minneapolis, MN 55440

INTRODUCTION

The Aeronomy Laboratory of NOAA has proposed to the National Science Foundation to construct a VHF ST radar near Urbana, Illinois for meteorological research. For the reasons given below, this site has been selected because it is located in flat terrain far from mountains.

An effort will be made to involve faculty members from university departments of meteorology and atmospheric sciences in experiments with this radar. It is believed that the combination of the Aeronomy Laboratory's experience with this type of radar, the meteorological expertise of the university faculty members and the meteorological consulting experience of Control Data Corp will be very productive in the further development of this technique as a meteorological tool. A university, private industry, and government effort is envisioned.

A wide range of experimental studies can be made at this radar as can be seen in the diverse subject matter covered in this Workshop on the Technical and Scientific Aspects of MST Radar. However, only three of the proposed experiments are emphasized here as examples.

DESCRIPTION OF RADAR

The Flatland radar will be a flexible ST radar configured for meteorological research. Its characteristics are summarized in Table 1. Continuous, unattended operation is anticipated. As this is a fourth or fifth generation radar, many features that have been found to be desirable in previous research will be incorporated in its construction. For example, its receiving system is designed to have a dynamic range of 100 dB to maintain linearity over the wide range of reflectivities encountered by an ST radar, and will be calibrated against a standard. The array antenna of the Flatland radar will be electronically steerable in the east-west and north-south vertical planes. It is anticipated that initial operation will be with five antenna beam positions as shown in Figure 1. This configuration has been tested at the Sunset radar and found to have many advantages. Velocities measured with redundant beam positions can be compared as in CLARK et al. (1983) or GREEN et al. (1986). The use of redundant beam positions has been found to be crucial to the interpretation of ST radar data near convective storms and will provide a better spatial average of both reflectivity and velocity. The rapid electronic steering of the radar antenna will allow 10 s (one Doppler spectrum per range gate) of data to be accumulated on each of the five beam positions each minute. These spectra will be saved in the on-line computer memory and at the end of a five-minute period, median spectra for each range gate and each direction will be recorded on magnetic tape (RASTOGI, 1984; GREEN, 1986). This rapid scan will prevent the aliasing of most gravity-wave modulation of radial velocity since the Nyquist period will be 2.5 min. This data-acquisition scheme is shown in Figure 2.

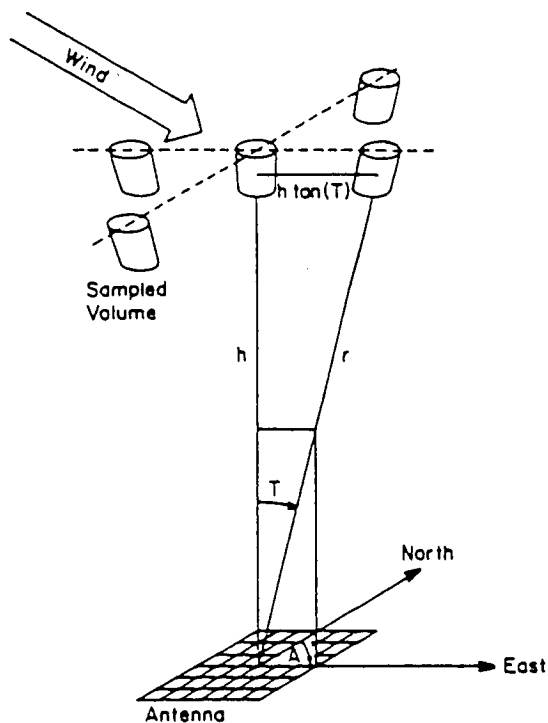


Figure 1. Location of beam positions. The relative location of the radar volumes at an arbitrary altitude corresponding to five radar antenna beam positions.

Antenna Pos	TIME						minutes
	0	1	2	3	4	5	
Vertical	x	x	x	x	x	x	calculate
15° North	x	x	x	x	x	x	median
15° South	x	x	x	x	x	x	spectra
15° East	x	x	x	x	x	x	and
15° West	x	x	x	x	x	x	record

Figure 2. Acquisition of data (one cycle) at the end of the observation cycle the median spectra for each range gate of every antenna position is individually calculated.

THE MEASUREMENT OF SYNOPTIC-SCALE VERTICAL VELOCITIES

One of the many experiments that can be performed with the Flatland radar is the measurement of the small vertical velocities associated with synoptic-scale meteorology. This velocity is the atmospheric variable most closely linked with weather, except perhaps moisture, yet it has been almost impossible to measure it directly. The Flatland radar, sited in very flat terrain, offers an opportunity to measure vertical velocity directly and continuously.

In a recent study (NASTROM, 1984), it was found that the time-averaged vertical motion over the Platteville, Colorado ST radar compared favorably with the computed synoptic-scale vertical velocity under certain synoptic conditions: when the prevailing winds were from the west, across the Rocky Mountains, the meteorological noise was too large to prevent computing a mean vertical velocity with sufficiently small statistical uncertainty, or else standing lee waves made the radar site unrepresentative of the large geographical area of the synoptic-scale system. In either case, it was a signal-to-noise problem induced by the mountains. A similar situation was found in the ALPEX data from Southern France (CARTER et al., 1984), i.e., when the winds were off the sea, the measured and computed vertical velocities agreed favorably, but when the winds were across the mountains, the agreement was poor or uncertain. Thus, we can conclude that at ST radar stations near the mountains, the synoptic-scale vertical velocity can be measured only under restricted conditions. These statistics suggest that it is probable that such a measurement can be made at the proposed Flatland radar which would be situated in very flat terrain far from mountains. As mentioned above, the proposed radar will also be capable of measuring the horizontal components of wind in the troposphere and lower stratosphere which can be used to sense the synoptic-scale systems.

COMPARISONS WITH THE URBANA RADAR

The Aeronomy Laboratory of the University of Illinois operates the Urbana radar. This radar, with its large power-aperture product, has made many observations in the stratosphere and mesosphere (ROYRVIK and GOSS, 1983). It is anticipated that the specialized meteorological measurements by the proposed Flatland would be compared to those of the Urbana radar in a study of troposphere-stratosphere-mesosphere coupling as in BOWHILL and GNANALINGAM (1986).

EXPERIMENTS IN COOPERATION WITH THE CHILL RADAR

A large Doppler microwave radar, the CHILL radar is located a few km from the site of the proposed Flatland radar (MUELLER and SILHA, 1978). This radar is operated by the Illinois State Water Survey. Since this microwave radar can measure the location and velocity of hydrometeors and the VHF ST radar can measure clear (or cloudy) air velocities, simultaneous observations by these two radars of stratiform or convective weather systems would provide unique and valuable meteorological information.

ADDITIONAL STUDIES

The radar data set recorded for the synoptic-scale vertical velocity experiment in a geographical region free from orographic effects would also be useful for studies of clear-air turbulence (VANZANDT, 1983; NASTROM, 1984), gravity waves (VANZANDT, 1986), transport of momentum by gravity waves (NASTROM and GREEN, 1986) tropopause morphology (VANZANDT and VINCENT, 1983; GAGE et

al., 1984) and tropopause height (GAGE and GREEN, 1982). This continuous data set could be used for the compositing of synoptic and mesoscale systems under various synoptic conditions. There is an intriguing possibility of estimating the thermal structure of the atmosphere from a combination of radar wind velocity and satellite radiance measurements (GAL-CHEN, 1986).

An effort will be made to attract experimenters with a wide range of meteorological sensors to special observational periods held at least once a year. Many of the additional capabilities inherent in the design of the proposed radar (variable altitude resolution, additional antenna positions, and real-time access to profiles of wind velocity and tropopause altitude) can be used, as required, in support of these experiments.

TABLE 1

Characteristics of the Flatland Radar

Location	South of Urbana, IL
Frequency	40.475 MHz
Wavelength	7.41 m
Antenna	
Type	Two collocated arrays of coaxial, collinear dipoles
Size	60 m x 60 m
Feed	Tapered to reduce sidelobes
Steerability (initial)	Five preset beam positions Vertical, 15° from the vertical to the north, south, east and west
Transmitter	
Peak power	100 kW
Average power	2 kW
Range Resolution	Variable 150 m to 2.4 km
Operation	Continuously sequence through 5 antenna positions.

REFERENCES

- Bowhill, S. A., and S. Gnanalingam (1986), Gravity waves in severe weather, this volume.
- Carter, D. A., B. B. Balsley, W. L. Ecklund, M. Crochet, A. C. Riddle, and R. Garelo (1984), Tropospheric gravity waves observed by three closely spaced ST radars, Handbook for MAP, 14, SCOSTEP Secretariat, Dep. Elec. Computer Eng., Univ. IL, Urbana, IL, 219-228.
- Clark, W. L., J. L. Green, and J. M. Warnock (1983), Estimating unbiased velocity components from MST/ST radar measurements: a case study, Handbook for MAP 9, SCOSTEP Secretariat, Dep. Elec. Computer Eng., Univ. IL, Urbana, IL 210-214.
- Gage, K. S., W. L. Ecklund, and B. B. Balsley (1984), A modified scattering model for the parameterization of Fresnel returns, Handbook for MAP, 14, SCOSTEP Secretariat, Dep. Elec. Computer Eng., Univ. IL, Urbana, IL, 88-97.
- Gage, K. S., and J. L. Green (1982), An objective method for the determination of tropopause height from VHF radar observations, J. Appl. Meteorol., 21, 1159-1163.
- Gal-Chen, T. (1986), A theory for the retrievals of virtual temperature from winds, radiances and the equations of fluid dynamics, this volume.

- Green, J. L. (1986), An example of scaling MST Doppler spectra using median spectra, spectral smoothing and velocity tracing, this volume.
- Green, J. L., J. M. Warnock, W. L. Clark, and G. D. Nastrom (1986), A comparison of vertical velocities measured by a VHF radar with specular and nonspecular echoes, this volume.
- Mueller, E. A., and E. J. Silha (1978), Unique features of the CHILL radar system, Preprints 18th Conf. on Radar Meteorology, Atlanta, GA, American Meteorology Society, 381-382.
- Nastrom, G. D. (1984), Synoptic scale dynamics with vertical velocity, Handbook for MAP, 14, SCOSTEP Secretariat, Dep. Elec. Computer Eng., Univ. IL, Urbana, IL, 62-68.
- Nastrom, G. D., and J. L. Green (1986), Preliminary estimates of vertical momentum flux, this volume.
- Rastogi, P. K. (1984), Criteria and algorithms for spectrum parameterization of MST signals, Handbook for MAP, 14, SCOSTEP Secretariat, Dep. Elec. Computer Eng., Univ. IL, Urbana, IL, 289-293.
- Royrvik, O., and L. D. Goss (1983), The Urbana MST radar, capabilities and limitations, Handbook for MAP, 9, SCOSTEP Secretariat, Dep. Elec. Computer Eng., Univ. IL, Urbana, IL, 346-356.
- VanZandt, T. E. (1983), Existence of a persistent background of turbulence, Handbook for MAP, 9, SCOSTEP Secretariat, Dep. Elec. Computer Eng., Univ. IL, Urbana, IL, 256-261.
- VanZandt, T. E. (1986), A model for gravity wave spectra observed by Doppler sounding systems, this volume.
- VanZandt, T. E., and R. A. Vincent (1983), Is Fresnel reflectivity due to low frequency boyancy waves? Handbook for MAP, 9, SCOSTEP Secretariat, Dep. Elec. Eng., Univ. IL, Urbana, IL, 78-80.